A Practical Image Retrieval Framework for Tourism Industry

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***Abstract*— Image Retrieval (IR) is one of the most exciting and fastest growing research domains in the field of multimedia technology. And in the industrial ecosystems, images of products, activities, marketing materials etc are needed to be managed and fetched in an efficient way to support and facilitate business processes. Current techniques for IR including keyword based, content based and ontology based image retrieval have several unsolved issues. We promote the ontology based IR approach and focus on two issues: firstly, the difficulty in constructing ontologies of images for those industries without ontology professionals, and, secondly, none of the existing approaches consider image content ranking in search results. In this paper, we propose a practical framework to tackle these issues by introducing an Abstract Image Ontology that serves as a blueprint of image ontologies and by incorporating a Concept Instance Ranking Scheme to allow ranking of each of the contents expressed in images, thus providing extra information for IR process. An application scenario in the tourism industry area is also presented.**

I. Introduction

The advent of the Internet has highlighted problems of IR. Currently, there are several million images spread across the Internet and this makes searching for the appropriate image a major concern. The problem is becoming even more serious as people have access to broadband internet services which allow easier uploading of images onto the web.

In such a scenario, the need for accurate and fast IR solutions is very crucial. Several approaches to IR have been presented in recent literature. Basically, there are two categories of approaches employed in IR: Content-Based IR (CBIR) and Meta-data-Based IR (MBIR).

Content-Based Image Retrieval (CBIR) addresses the problem of finding images relevant to the users' information needs based, principally, on low-level visual features for which automatic extraction methods are available [1, 12]. Visual features such as dominant colour, colour histogram, texture, object shape and the like are used for IR in CBIR techniques. The problem with CBIR, however, is that it is highly objective and sometimes may not be able to capture all intended meanings from an image and, hence, can give unexpected results when queried by a search engine. There is a semantic gap between the low-level image features and high-level human understandable concepts. It also requires lot of feedback from users to improve the quality of the search result which is also termed as relevance feedback.

On the contrary, in MBIR, the image retrieval is based on the descriptions assigned to the images by its users or creators [2]. There are two basic approaches for MBIR: Keyword-Based IR (KBIR) and Ontology-Based IR (OBIR).

Keyword based search is normally used to retrieve images from a database. Users can typically query the database fields using several filters or keywords such as 'owner', 'object', 'location' and so forth and retrieve appropriate images. KBIR systems have been widely used, however, it has two major issues as pointed out by Hyvonen, Saarela and Viljanen [2]: firstly, the problem with the quality of search results and, secondly, the problem with usability of such systems.

On the other hand, OBIR uses semantically richer ontology based annotations to describe images. Such annotations are not atomic keywords but can be more detailed structured descriptions that are linked with other resources in a semantic graph. The main advantage of using ontologies in IR is that it can increase precision and reduce ambiguity which, in turn, results in better precision and recall rates. The main issue with OBIR is that it takes enormous amount of manual work during the construction of the ontologies. Furthermore, it is difficult to construct a user friendly graphical interface to capture all the desired information about an image. However, once this matter is solved, it would be the most reliable and favoured solution for IR.

Another major concern with both the MBIR approaches is that the meta-data, whether it is keywords in KBIR or concepts in OBIR, are equally important with searching. For example, an image of a 'Swan' taken at a 'River' in 'Perth' can be tagged using the following keywords: 'Swan', 'River' and 'Perth'. Hence, a keyword search for all of these keywords would result in this image being retrieved. However, if the user's intention is to find 'Perth City', the possibility of this image being listed in the top 20 cannot be ruled out. The main reason for this scenario is because all the contents of the image are given a uniform ranking. They are not given any unique ranking (or weighting) which would be helpful in assigning the importance of one content (amongst a set of contents) to one image.

As shown in the Fig. 7, the main content of this image is the windmill but along with the windmill the image also shows sky

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and mountain. Here, the windmill is most important concept and when the term 'windmill' is searched this image should be listed first. However, in case the term 'sky' or 'land' is searched it should not be ranked as the first result.

In this paper, we address these issues by proposing a framework for generating ontologies for given images and assigning different rankings to concept instances that are used to explicitly describe images. The paper is structured as follows: section 2 describes related work in the field of IR; section 3 introduces the proposed OntoImage Framework in detail; section 4 gives application scenario in tourism industry; and section 5 concludes the paper and highlights future works.

II. LITERATURE REVIEW

In this section, we outline the work that has been done in the field of image retrieval based on different approaches like CBIR, KBIR and OBIR.

The most commonly used approach for image retrieval is text based, where the image is automatically annotated by smartly parsing surrounding textual information from a web page. Many commercial text based image retrieval systems are available on the Internet, most common being Google Image [8] and Yahoo Image Search [9].

The second approach is based on analysing the primitive image features like colour, texture, shape and so forth. A lot of work has been done in this area [3, 4, 5, 6]. As pointed out by Eakins [1], this approach is mostly useful in specialist applications like location of drawing in a design archive or registration of trademark images or colour matching and comparisons in fashion accessories. A recent approach [11] uses Self-Organising Maps for CBIR of web pages and other hierarchical objects. One of the major problems with such CBIR systems is that their objective similarity may or may not match the user's subjective and context-dependent requirements. Hence, alternative approaches to IR like the MBIR were explored by researchers in the last few years.

The third approach is based on retrieval by keyword annotations. Keyword based image retrieval and annotation systems are lately seen with the development of Flickr [7] – a commercial photo sharing portal, where users can upload their photos and tag it with keywords and share them over the internet. The approach described by Viitaniemi and Laaksonen [10] considers automatic annotation of images with keywords. They propose a new information-theory based measure termed de-symmetrised mutual information (DTMI) for automation. To address the issues with CBIR, another novel approach is presented in Kutics, Nakagawa, Tanaka, Yamadat, Sanbe and Ohtsuka [13]. This proposal firstly extracts the salient image objects and also their structural and visual features. Later, keywords and images are linked in two stages; first by mapping low-level visual features of objects to related words using feature lexicons and, secondly by assigning words expressing higher-level semantic concepts to images on the basis of the feature-related words, lexical definitions and the user's relevance feedback.

A more advanced approach for keyword based annotation can be achieved by using semantically rich ontologies. Work in this area has recently started and very few papers address the problem of IR using ontologies. Silva, Mastella, Galante and De Ros present an ontology based approach for image annotation and interpretation [14]. They argue that it is a challenging task to annotate abstract concepts from an image and, hence, domain experts would be required to facilitate the capture of this domain knowledge. They present a domain level ontology for studying rock formation images. A similar attempt to understand higher level abstract concepts are presented in [15]. Here, the main focus is on identifying objects within an image which match the user queries.

We understand that most of the literature on IR has not addressed the issues that we have highlighted earlier. Hence, we propose the OntoImage framework to solve these issues.

III. PROPOSED ONTOIMAGE FRAMEWORK

In this section, we briefly introduce the preliminary concept of ontology which would be useful in understanding the proposed OntoImage Framework. We then describe the proposed OntoImage framework in detail.

A. Preliminary Concept - Ontology

An ontology is defined as 'a (formal) explicit specification of (shared) conceptualization' [16]. Knowledge modelled by ontologies is unambiguous and explicit. The representation of ontology is formal and uses formal logic language such as F-logic [19] and OWL [17], which means that it can be processed by software agents. Thus, the knowledge represented by ontologies becomes sharable and reusable across application and organisation boundaries without prior negotiation. This is achieved by defining each concept with its related concepts by specifying explicitly how each concept should be used and by achieving agreement on all the definitions of an ontology within a community of interest. Nowadays ontology-based solutions have been widely proposed in many research areas such as AI, knowledge engineering, multi-site project management, system engineering and web search engine such as Semantic Web [18] and the like.

We now propose the OntoImage Framework based on ontology for smart image retrieval.

B. Proposed OntoImage Framework

Overview - OntoImage Framework

The OntoImage framework is designed for providing a simple, effective and convenient means of generating an image ontology in OWL for any given image. The generated image ontology represents the image as a knowledge model of that image in a more accurate, explicit and complete way for intelligent image retrieval. Besides, each of the contents within an image is assigned a weight ranging from 1 to 10 to indicate the importance of that content in the overall image. This feature would provide more information to search engines in deciding the relevance of the image to the user query. The proposed framework is depicted in Fig 1.

The framework is based on two key components: the Abstract Image Ontology component that provides the generic concept of 'image' (conceptualisation) and the Concept Instance Ranking Scheme (CIRS) component that provides importance ranking of each of the concept instances expressed in an image.

The Abstract Image Ontology model is shown in Fig. 2. The abstract image ontology models the generic concept of images in six classes, namely: Image, Physical_Object, Abstract_Concept, Time, Color, and Location (The class hierarchy is shown in Fig. 3). The image class has five properties, namely: name, author, creation_time, dominant_color and content (Shown as in Fig. 4). The content of an image can be any of the instances of other classes. The content instances are created from user inputs through a user friendly interface. Each of the classes can be further elaborated according to user recommendations. Therefore, the abstract image ontology will be evolved over time to represent more agreed knowledge of images. This ontology is published along with the framework at the following URL: (http://www.ceebi.curtin.edu.au/ontoImage/).

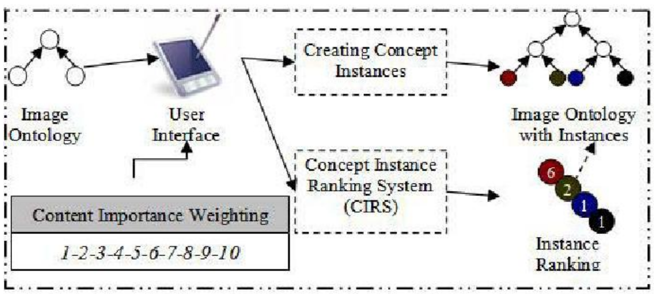

Fig. 1. Proposed OntoImage Framework Model

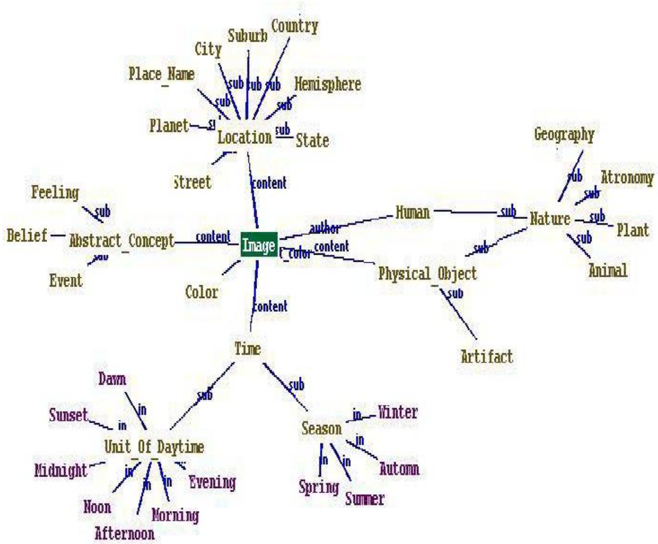

Fig. 2. Abstract Image Ontology Model

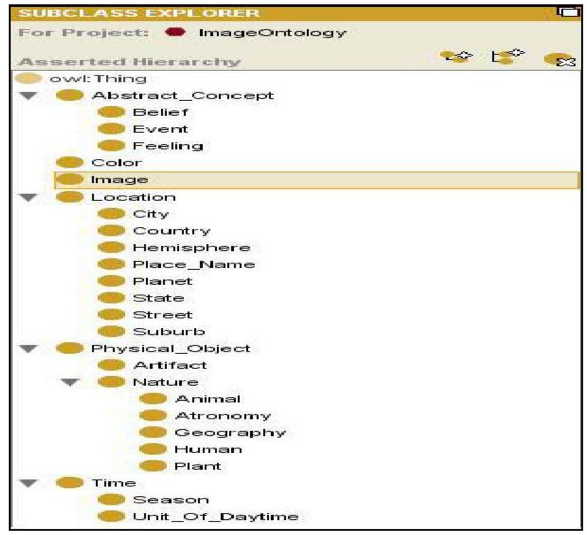

Fig. 3. Image ontology class hierarchy shown in Protégé

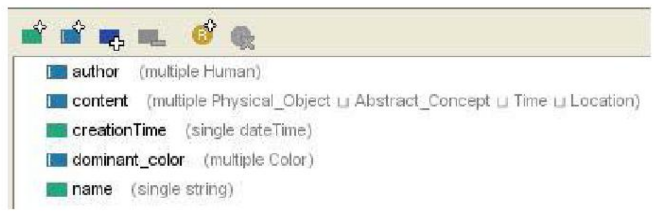

Fig. 4. Properties of Image Class

Another important part of the proposed framework is the Concept Instance Ranking Scheme (CIRS). The proposed CIRS takes relevant input from the user to decide ranking of concepts that are associated with an image. A simple graphical user interface to capture these inputs from the user is shown in Fig. 6. We propose two implementations of the ranking schemes and we plan to do a comparative study on its results in the future.

In the first scheme, we assign a value from 1 to 10 to describe each concept and its relevance to the main theme of the image. The value 1 represents least relevant and 10 represents the most relevant as shown in Fig. 5. The system can then be trained to provide more accurate results. User participation is highly crucial for the success of this approach. In the second scheme, we limit the total importance weight to 10, which is the sum of the total weight that users assign to the concept instances cannot exceed this limit.

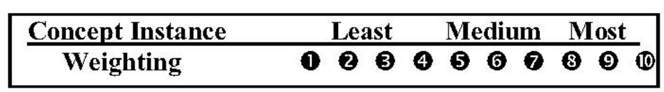

Fig. 5. Content Importance Weighting

Process of an ontology generation

The process of generating image ontology of a given image contains three steps:

Step 1. User inputs relevant concept instances of the abstract image ontology for an image. The abstract image ontology model is represented in a user friendly form, which gives user clues of possible information about one image that can be inputted. Each input then becomes a concept instance of the abstract ontology model.

Step 2. User assigns the Content Importance Weight to each of the created concept instances.

Step 3. The framework generates an ontology of the given image with the concept instance ranking based on the abstract ontology model and user inputs. Thus, information of an image is represented by the generated image ontology through ontological instances creation of the abstract image ontology. Then the generated ontology can be published on the internet representing the original image for image retrieval.

OntoImage User Interface

The user interface of the OntoImage framework has been created for demonstration purposes at the following URL: http://www.ceebi.curtin.edu.au/ontoImage. A screenshot is shown in Fig. 6.

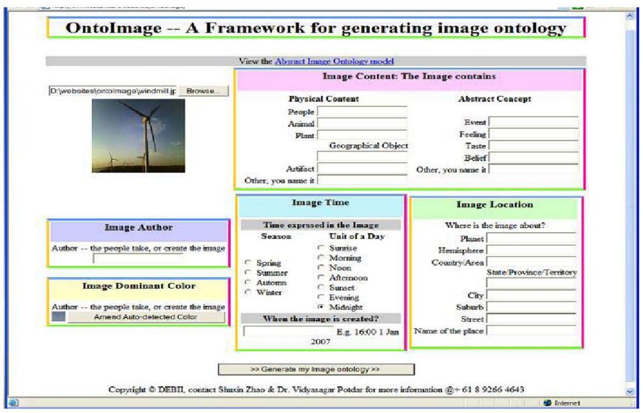

Fig. 6. Proposed OntoImage User Interface for creating specific Image Ontology

IV. APPLICATION SENARIO IN TOURIST INDUSTRY

This section applies the OntoImage framework for image retrieval in the area of tourism industry and gives an example of a specific image ontology generated based on the proposed framework. A country such as Australia receives, on an average, about 350,000 to 400,000 tourists/visitors every month [20]. They explore many unexplored areas on the Australian subcontinent, many of which are not even listed or marketed by the tourism department. If these tourists are provided with the OntoImage framework to describe and share their photographs online, it would definitely strengthen the tourism industry. The framework would be made available at all major tourist destinations across Australia to attract tourists to share their photographs and help develop the Australian tourism industry. As a consequence we would be able to develop a massive tourism databases which could then be used to attract new tourist and in turn generate additional job opportunities in regional Australia and increase tourism income. An example of the proposed framework is shown in Fig. 7 & 8. Fig. 7 shows the image shared by the tourists whereas Fig. 8 shows the respective ontology.

An ontology of “Windmill” is created as an instance of the proposed Abstract Image Ontology as in Fig. 8.

The content instances of the windmill ontology are ranked as follows:

Content: *Physical_Objectt→ Artifacts →windmill (8)*
Content: *Physical_Object→Nature→ Geograph →sky (1)*
Content: P*hysical_Object→Nature→Geograph→mountain (1)*
Content: *Location→Planet → Earth →Hemisphere→ The Southern Hemisphere → Country→Australia →State →WA→ →City→Albany→PlaceName→Albany Wind Farm (7)*
Content: *Time → Unit_of_Daytime → sunset (5)*
Content: *Time → Season → summer (2)*

In this way, photographs of tourist sites, landmarks, and special sceneries can be explicitly shared and searched based on users’ preferences and searching target. Images in the search result are also listed in accordance with their content ranking scale and the requested search target.

Fig. 7. Example image for creating specific ontology

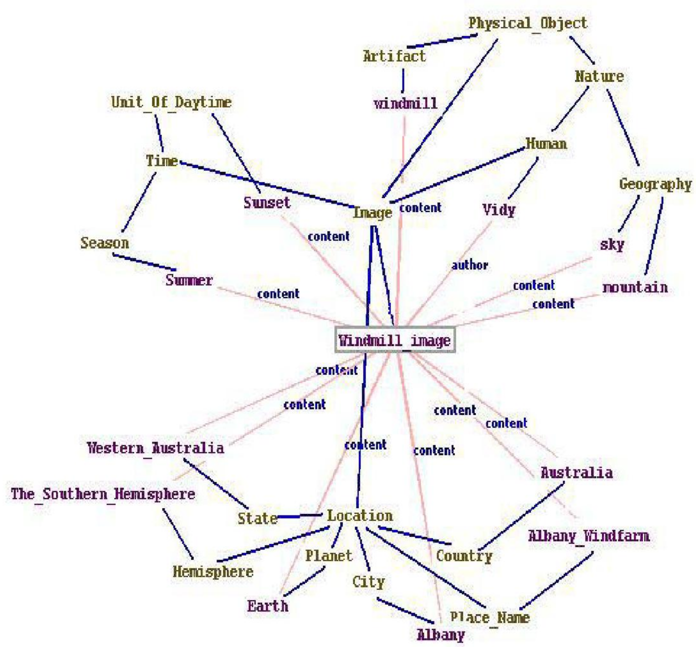

Fig. 8. Windmill Ontology

V. CONCLUSION AND FUTURE WORK

In this paper, we proposed an Ontology based IR framework termed 'OntoImage'. We promoted the ontology based IR approach and addressed two main issues; to provide an easy user interface to annotate images using ontology and, secondly, to facilitate novice users to construct ontology for their images. The novelty of our approach was the use of CIRS which assigned different weights to different concepts in an image. This technique would facilitate search engines to provide more accurate results. In the future, we will perform a comparative study to observe the effects the two proposed CIRS approaches.

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